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GB 1591842 A

(58) Field of Search
UK CL (Edition L) B5K
INT CL[5] B29C

(54) Bonding tubes to articles e.g in making panel heat exchangers.

(57) A method of bonding a thermoplastic polymer tube to a thermoplastic polymer article to form a fluid flow passage therethrough comprises inserting the tube 11 into a channel extending through the article from a first side thereof so that the tube protrudes through and beyond the second side of the article 1, inserting a metal rod 14 into the tube 11 so that the metal rod 14 protrudes beyond the tube on the second side of the article, and contacting the tube protruding beyond the article with an elongated sealing element 7 having an axial recess in the tip thereof. The axial recess is adapted to accommodate the metal rod in sliding engagement. The sealing element is moved towards the second side of the article, melting the thermoplastic polymers of the tube and article and forcing the polymer 16 into recessed and bevelled sections of the article channel. In preferred embodiments, the sealing element is an ultrasonic sound sealing element.

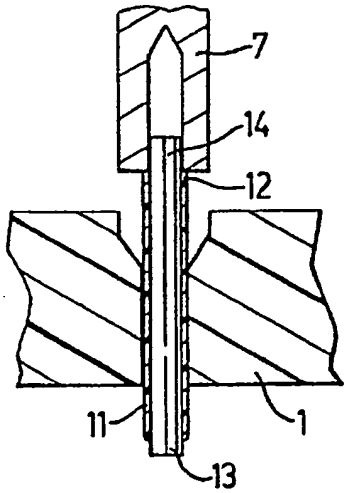

FIG. 2

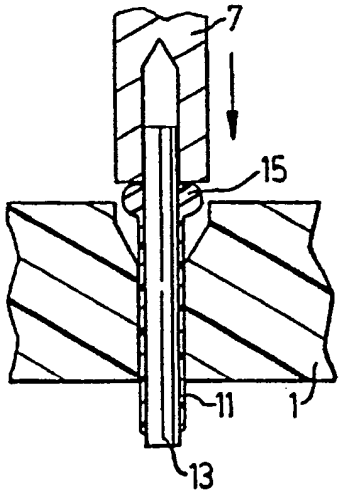

FIG. 3

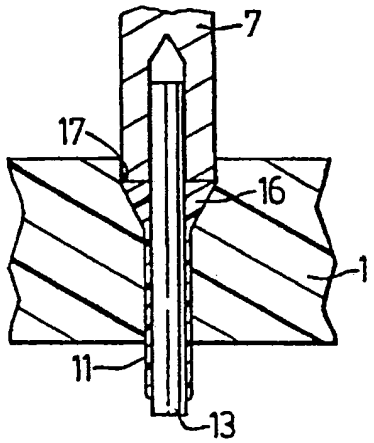

FIG. 4

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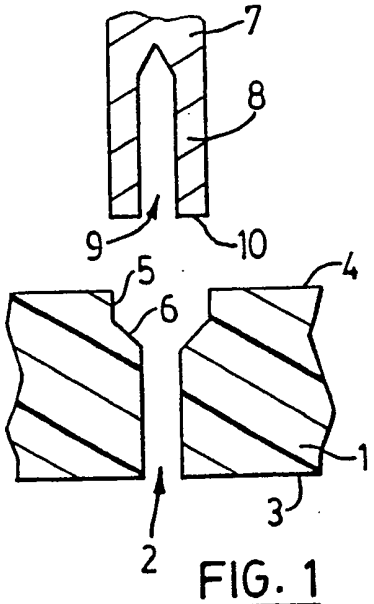

FIG. 1

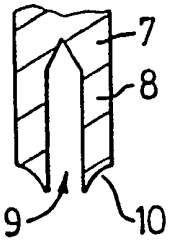

FIG. 1A

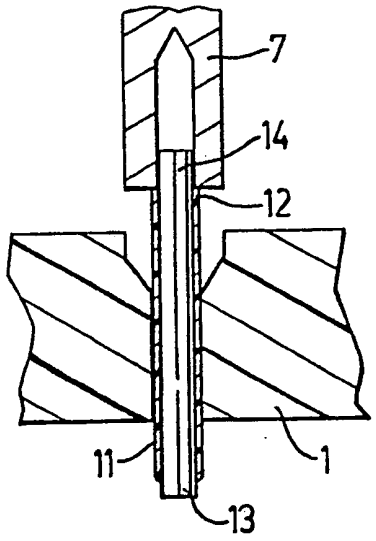

FIG. 2

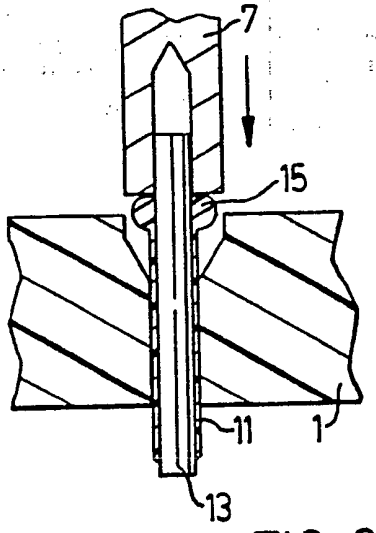

FIG. 3

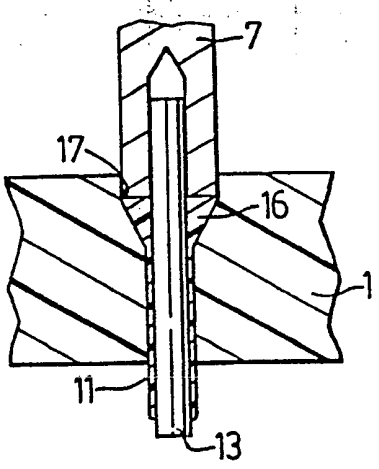

FIG. 4

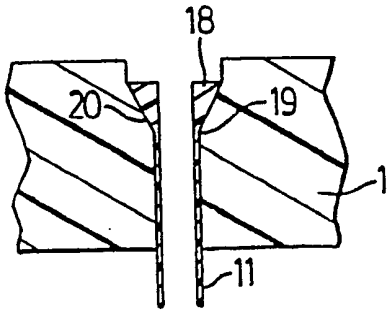

FIG. 5

BONDING OF TUBES TO ARTICLES

The present invention relates to a method of bonding tubes to articles, especially channelled articles and preferably articles in the form of channelled plates, so as to provide fluid flow communication between the tubes and channels through the articles. In particular, the method relates to the bonding of tubes into plates in the manufacture of heat exchangers.

Panel heat exchangers formed from thermoplastic polymers and methods for the manufacture of such heat exchangers are known. For instance, a number of heat exchangers formed from thermoplastic polymers and methods for the manufacture thereof are disclosed in PCT patent application WO91/02209 of A.J. Cesaroni, published 1991 February 21, and in the published patent applications referred to therein. Thermoplastic polymer heat exchangers of a tubular construction are described in U.S. Patents 4 923 004, issued 1990 May 08, and 5 078 946, issued 1992 January 07, both of E.L. Fletcher and T.H. Kho, in which tubes are integrally formed with a manifold section in a moulding or similar process. A preferred material of construction for the heat exchangers is aliphatic polyamide.

While heat exchangers formed from thermoplastic polymers have been fabricated by the techniques described in the above patents and published patent applications, improvements in the construction and methods of fabrication would be beneficial to add further flexibility and economy to the fabrication and use of heat exchangers formed from thermoplastic polymers. In particular, assembly of tubes into plates or other structures in the manufacture of tube heat exchangers is usually a tedious and time-consuming process, often involving use of adhesives to bond the tubes into plates.

A method for the bonding of thermoplastic polymer

tubes into thermoplastic polymer articles in a fluid-tight manner has now been found.

Accordingly, the present invention provides a method of bonding a thermoplastic polymer tube to a thermoplastic polymer article to form a fluid flow passage therethrough, said article having a channel extending from a first side of the article to a second side thereof, said channel exiting from the article at the second side through a bevelled section and a recessed section, comprising in sequence the steps of:

(a) inserting the tube into the channel from the first side of the article so that the tube protrudes through and beyond the second side of the article;

(b) inserting a metal rod into the tube so that the metal rod protrudes beyond the tube on the second side of the article, said rod slidingly engaging said tube;

(c) contacting the tube protruding beyond the article with an elongated sealing element having an axial recess in the tip thereof, said axial recess being adapted to accommodate the metal rod in sliding engagement, said sealing element having a diameter that is slightly larger than the recess section in the article and being capable of melting the polymers of the tube and the article;

(d) moving the sealing element towards the second side of the article so that the tip thereof enters the recess section to a depth substantially equal to the depth of the recess section, said sealing element melting the thermoplastic polymer of the tube and thermoplastic polymer surrounding the recess section of the article and forcing such polymer into the recessed and bevelled sections of the article;

(e) withdrawing the sealing element from the article;

(f) when the thermoplastic polymer has cooled sufficiently, withdrawing the rod from the tube;

(g) operating said method so that a fluid tight seal is

formed between the tube and the article, said tube providing a fluid communication passage through the article.

In a preferred embodiment of the method of the present invention, the sealing element is an ultrasonic sound sealing element.

In another embodiment, the tube slidingly engages the channel.

In a further embodiment, the thermoplastic polymers of the tube and of the article are compatible when molten.

In yet another embodiment, the sealing element is of the same cross-sectional shape as the channel.

In a still further embodiment, in step (b), the metal rod is inserted into the tube from the first side of the article.

The method of the present invention will be particularly described with reference to the embodiments shown in the drawings, in which:

Fig. 1 is a schematic representation of a channelled article and a sealing element, with Fig. 1A showing the tip of the sealing element;

Fig. 2 is a schematic representation of the article of Fig. 1 with the tube and rod in place;

Fig. 3 is a schematic representation of the article during movement of the sealing element;

Fig. 4 is a schematic representation of the article with the sealing element in the fully extended position; and

Fig. 5 is a schematic representation of the article after the tube has been bonded.

Referring to Fig. 1, article 1 is shown as having a channel 2 extending from the first side 3 to the second side 4 of the article. Channel 2 is shown as having a uniform cross-section over the major portion of its length. However, the section of channel 2 near second

side 4 is shown as having recess section 5 and bevelled section 6, such that the diameter of channel 2 increases at bevelled section 6 in a continuous manner to the diameter of recess section 5. Sealing element 7, shown in part, has end element 8 located above recess section 5; as discussed below, end element 8 has a diameter that is slightly larger than the diameter of recess section 5. End element 8 has axial orifice 9 located in tip 10 thereof. Tip 10 is shown as having a square cross section, but in an embodiment tip 10 is concave, as shown in Fig. 1A.

Fig. 2 shows article 1 and sealing element 7 as described above. In addition, tube 11 is shown as being located in channel 2, with tube 11 extending away from both first side 3 and second side 4 of article 1. Tube 11 extends away from first side 3 for a considerable distance, as determined by the design of the article. Tube 11 extends away from second side 4 for a short distance, which is referred to herein as protruding from second side 4; tube 11 protrudes to an extent less than the distance between second side 4 and tip 10 of sealing element 7. However, as shown in Fig. 2, tip 10 is in contact with end 12 of tube 11 due to tip 10 being moved into such contact. Tube 11 is shown as being in sliding engagement with the surface of channel 2, prior to bevelled section 6 and recess section 5. Rod 13 is located within tube 11, and in sliding engagement therewith, with rod end 14 extending beyond end 12 of tube 11 and into axial orifice 9.

Fig. 3 shows the next stage in the method, with sealing element 7 moving towards article 1. Sealing element 7 may be a heated element or, preferably, an ultrasonic sealing device, such that sealing element 7 causes tube 11 to melt, forming melt pool 15. Rod 13 is shown as being stationary, although it is not necessarily

so.

Fig. 4 shows sealing element 7 in its fully extended position, extending beyond second side 4 and into recess section 5. As sealing element 7 has a diameter greater than the diameter of recess section 5, sealing element 7 has contacted and melted part of edge 17 of recess section 5. The polymer of tube 11, melted in the form of melt pool 15 together with molten polymer from edge 17 has formed molten polymer 16 which is located in bevelled section 6 of channel 2.

Fig. 5 shows article 1 having tube 11 bonded thereto. Polymer block 18 has been formed in bevelled section 6 of channel 2. Polymer block 18 is connected to and forms part of tube 11 at junction 19 and is bonded to article 1 along bond 20.

In operation, tube 11 is inserted into channel 2 of article 1 so that tube 11 protrudes beyond second side 4 of article 1. Metal rod 13 is inserted into tube 11 from first side 3, so that it extends beyond tube 11 on second side 4 of article 1. Sealing element 7 is brought into contact with the end of tube 11, with the end of rod 13 entering axial orifice 9 of tip 10 of sealing element 7; this maintains the alignment of tube 11, article 1 and sealing element 7, and ensures that tube 11 melts without collapsing and causing a restricted or an absence of fluid flow passage through tube 11.

Sealing element 7 is moved towards article 1 (or conversely article 1 is moved towards sealing element 7) to the extent that sealing element 7 contact the edge of recess section 5; as discussed above, tip 10 of sealing element 7 has a diameter that is greater than, preferably only slightly greater than, the diameter of recess section 5 to permit melting of polymer of the edge of recess section 5. Molten polymer from tube 11 together with molten polymer from the edge of recess section 5 is

forced by tip 10 into the region of bevelled section 6. Sealing element 7 is then withdrawn from article 7 and, after a period of time sufficient to permit cooling of the molten polymer, rod 13 is withdrawn from tube 11; the period of time for the cooling will normally be very short because the relatively cool article 1 will act as a heat sink as soon as sealing element 7 is withdrawn, resulting in rapid solidification of the molten polymer. If an ultrasonic sound sealing element is used, the power applied is preferably reduced from an initial high value to a lower value as the sealing element enters the recessed section.

In an embodiment, the surface of the recess section and/or the bevelled section is coated with an adhesive, to promote bonding of the tubing to the article. Examples of an adhesive are given in European patent application No. 287 271 of A.J. Cesaroni, published 1988 October 19.

In preferred embodiments, the tubes and article may be formed from a variety of polyamide compositions. The composition selected will depend primarily on the end use e.g. the end use intended for a heat exchanger fabricated using the method described herein, especially the temperature of use and the environment of use, including the fluid that will be passed through such a heat exchanger and the fluid e.g. air, external to the heat exchanger. In the case of use of such a heat exchanger on a vehicle, the fluid may be air that at times contains salt or other corrosive or abrasive matter, or the fluid may be liquid e.g. radiator fluid.

A preferred polymer of construction is polyamide. Examples of polyamides are the polyamides formed by the condensation polymerization of an aliphatic dicarboxylic acid having 6-12 carbon atoms with an aliphatic primary diamine having 6-12 carbon atoms. Alternatively, the

polyamide may be formed by condensation polymerization of an aliphatic lactam or alpha,omega aminocarboxylic acid having 6-12 carbon atoms. In addition, the polyamide may be formed by copolymerization of mixtures of such dicarboxylic acids, diamines, lactams and aminocarboxylic acids. Examples of dicarboxylic acids are 1,6-hexanedioic acid (adipic acid), 1,7-heptanedioic acid (pimelic acid), 1,8-octanedioic acid (suberic acid), 1,9-nonanedioic acid (azelaic acid), 1,10-decanedioic acid (sebacic acid) and 1,12-dodecanedioic acid. Examples of diamines are 1,6-hexamethylene diamine, 1,8-octamethylene diamine, 1,10-decamethylene diamine and 1,12-dodecamethylene diamine. An example of a lactam is caprolactam. Examples of alpha,omega aminocarboxylic acids are amino octanoic acid, amino decanoic acid and amino dodecanoic acid. Preferred examples of the polyamides are polyhexamethylene adipamide and polycaprolactam, which are also known as nylon 66 and nylon 6, respectively.

While particular reference has been made herein to the use of polyamides as the polymer used in the fabrication thereof, it is to be understood that other polymers may be used. A principal consideration in the selection of the polymers of the article and the tubing is that the polymers need to be thermoplastic polymers, and preferably polymers that are compatible in the molten form. Compatible molten polymers will result in stronger bonds being formed to maintain the tubing bonded to the article, and hence retain integrity of the fluid tight seal of tubing and article. In addition, the environment of use of articles fabricated using the method of the invention, for example a heat exchanger and the properties of the fluid passing through and over such a heat exchanger, the temperature and pressure of use and the like, are important. Examples of other thermoplastic

polymers that may be used are polyethylene, polypropylene, fluorocarbon polymers, polyesters, thermoplastic and thermoset elastomers e.g. polyetherester elastomers, neoprene, chlorosulphonated polyethylene, and ethylene/- propylene/diene (EPDM) elastomers, polyvinyl chloride and polyurethane.

In preferred embodiments of the present invention, the tubing used in the fabrication of the panel heat exchanger has a thicknesses of less than 0.7 mm, and especially in the range of 0.07-0.50 mm, particularly 0.12-0.30 mm. The thickness of the tubing will, however, depend to a significant extent on the proposed end use and especially the properties required for that end.

The polymer compositions used in the fabrication of the heat exchangers may contain stabilizers, pigments, fillers, including glass fibres, and the like, as will be appreciated by those skilled in the art.

The polymer composition of the tubing and of the sheet may be the same or different, depending on the intended use of the fabricated articles. All seals should be fluid tight seals, especially in a heat exchanger, to prevent leakage of fluid from the heat exchanger.

The method of the present invention provides a versatile and relatively simple method of fabricating heat exchangers. Heat exchangers may be used in a variety of end-uses, depending on the polymer(s) from which the heat exchanger has been fabricated and the intended environment of use of the heat exchanger. In embodiments, the panel heat exchangers may be used in automotive end uses e.g. as part of the water and oil cooling systems. The panel heat exchangers may also be used in less demanding end uses e.g. in refrigeration and in comfort heat exchangers.

The present invention is illustrated by the

following examples.

Example I

Tubes having an outer diameter (OD) of 4.3 mm and a wall thickness of 0.36 mm were formed from polyhexamethylene adipamide in an extrusion process. The article used in this Example was in the form of a block of polyhexamethylene adipamide having a thickness, from the first side to the second side, of approximately 10-12 mm. Holes (channels) having a diameter slightly greater than the OD of the tubing were drilled through the article from the first side to the second side; previous testing had shown that the tubing could have a "snug" fit within the holes or a relatively loose fit, without major effects of the process. The channels exiting from the second side of the article were recessed and bevelled in the manner shown in the Figures, with the recess section being circular in cross-section and with a diameter slightly smaller than the sealing tool to be used.

Tubing was inserted into the holes in the article from the first side, so that the end of the tubing protruded beyond the recess section on the second side of the article for a short distance (a few millimetres). A metal rod was then inserted into the tubing from the first side, so that the end of the metal rod extended beyond the end of the tubing for a distance of about 3 mm.

An ultrasonic sealing device was used to seal the tubing into the article. The ultrasonic sealing device had been fabricated in the laboratory. The sealing device had a so-called exponential horn with the elongated tip having a recess extending back into the tip that was of dimensions to accommodate the metal rod; there was clearance between the metal rod and the walls of the recess. The ultrasonic sealing device was capable of being used at 150 watts (low power) up to 250 watts

(high power), at the tip of the sealing device. The ultrasonic sealing device was capable of being used at frequencies in the range of 9-100 kHz, and was tuned at 23 kHz.

The horn of the ultrasonic sealing device was placed over the metal rod and a high initial power was applied. The horn of the sealing device was then moved towards the tubing and article, whereupon the tubing melted with the molten polymer being forced into the recess section; the power applied was reduced as the horn of the sealing device entered the recessed section. As the horn entered the recess section, it contacted and melted a thin section of polymer around the edge of the recess section; this polymer was also forced into the recess section. The horn was inserted into the recess section for a distance that calculations had shown resulted in molten polymer filling the recess section and bevelled section in the article. The horn was then removed. The article allowed to cool and then the rod was removed.

The sealing procedure was then repeated with other holes in the article.

Subsequent pressure testing showed that an air tight seal had been formed between the article and the tubing.

CLAIMS:

1. A method of bonding a thermoplastic polymer tube to a thermoplastic polymer article to form a fluid flow passage therethrough, said article having a channel extending from a first side of the article to a second side thereof, said channel exiting from the article at the second side through a bevelled section and a recessed section, comprising in sequence the steps of:

(a) inserting the tube into the channel from the first side of the article so that the tube protrudes through and beyond the second side of the article;

(b) inserting a metal rod into the tube so that the metal rod protrudes beyond the tube on the second side of the article, said rod slidingly engaging said tube;

(c) contacting the tube protruding beyond the article with an elongated sealing element having an axial recess in the tip thereof, said axial recess being adapted to accommodate the metal rod in sliding engagement, said sealing element having a diameter that is slightly larger than the recess section in the article and being capable of melting the polymers of the tube and the article;

(d) moving the sealing element towards the second side of the article so that the tip thereof enters the recess section to a depth substantially equal to the depth of the recess section, said sealing element melting the thermoplastic polymer of the tube and thermoplastic polymer surrounding the recess section of the article and forcing such polymer into the recessed and bevelled sections of the article;

(e) withdrawing the sealing element from the article;

(f) when the thermoplastic polymer has cooled sufficiently, withdrawing the rod from the tube;

(g) operating said method so that a fluid tight seal is formed between the tube and the article, said tube providing a fluid communication passage through the

article.

2. The method of Claim 1 in which the sealing element is an ultrasonic sound sealing element.

3. The method of Claim 1 or Claim 2 in which the tube slidingly engages the channel.

4. The method of any one of Claims 1-3 in which the thermoplastic polymers of the tube and of the article are compatible when molten.

5. The method of any one of Claims 1-4 in which the sealing element is of the same cross-sectional shape as the channel.

6. The method of any one of Claims 1-5 in which in step (b), the metal rod is inserted into the tube from the first side of the article.

7. The method of any one of Claims 1-6 in which the tube and article are formed from thermoplastic polyamide.

8. The method of any one of Claims 1-7 in which the article is a panel heat exchanger.

9. Methods according to claim 1 substantially as herein described with reference to the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9226553.7

Relevant Technical fields

(i) UK Cl (Edition) B5K

(ii) Int Cl (Edition) B29C

Search Examiner
A HABBIJAM

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
10 MARCH 1993

Documents considered relevant following a search in respect of claims 1-9

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 1591842 (SERCK INDUSTRIES)	

		to clai

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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